NASA-CR-97- 206120

Contract No: NAS 3-27541
"Low Cost Pressure Infiltration Casting of Reinforced Superalloy Components"

INTERIM
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OCIT
101049

Creep Testing Report as the partial section of final report for NAS3-27541

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1.0 Experiments Procedure

Based on the results of ambient temperature and 800C flexure testing on the various reinforced superalloys evaluated in this project, four composite materials were chosen for creep testing at 800°C. Namely: IN-100 superalloy reinforced with alumina particulate, IN-100 superalloy reinforced with Nextel fiber, IN-100 superalloy reinforced with a hybrid of Nextel fiber and alumina particulate, and IN-713 superalloy reinforced with a hybrid of Nextel fiber and alumina particulate.

Since we were limited to casting simple cylindrical shapes, specimens of 0.25 in diameter were chosen for creep testing. The creep specimens were designed and fabricated with IN-718 grip sections shrink-fitted onto cast bars. In order to encourage specimen failure within the gage section, the gage sections were reduced in diameter by approximately 0.030". All of the specimen were ground to size, and then assembled by heating IN718 grip adapters to above 900°C. An interference of at least 0.0015" at the test temperature of 800C was designed to provide adequate shear strength for creep testing. After the specimens were assembled, the gage sections of specimens were ground and adapters were threaded. Creep test of the four materials were carried out at 800°C by Metcut Research Associates of Cincinnati. Table 1 shows the design of creep test for these four materials.

Table 1. The specimen list for creep testing at 800°C

Specimen	Material	Desired Stress for Creep Testing (ksi)	Applied Load for a diameter of 0.208"(lb.)
1	IN-100 with alumina particulates	35	1189
2	IN-100 with alumina particulates	10	340
3	IN-100 with Nextel alumina fiber	35	1189
4	IN-100 with Nextel alumina fiber	10	340
5	IN-100 with both Nextel alumina fiber and alumina particulates	35	1189
6	IN-100 with both Nextel alumina fiber and alumina particulates	10	340
7	IN-713 with both Nextel alumina fiber and alumina particulates	50	1699
8	IN-713 with both Nextel alumina fiber and alumina particulates	14.5	493

In estimating these creep stresses, the measured flexure strengths were divided by 1.6 to arrive at approximate yield strength. The creep strengths were specified roughly equal to 20% and 70% of these values. For IN100 composites, creep stresses of 10 and 35 ksi were specified. Creep stresses of 14.5 and 50 ksi were selected for the For the IN713 composites.

2.0 Testing Result and Discussion

The creep testing results are shown in Table 2.

Table. 2 The results of creep testing of high temperature metal matrix composites .

Speci men No.	Materials	Temp C (F)	Stress ksi(MPa)	Duration (hours)	Results	Plastic Strain on Loading	Final Creep	Elongation (%)
1	IN100/Al_2O_3p	800(1472)	35(136)	FOL	Adapter	---	---	---
2	"	800(1472)	10(69)	1177.7	Discontinued	0.00	0.06	-0.10
3	IN100/Al_2O_3f	800(1472)	35(136)	FOL	Adapter	---	---	---
4	"	800(1472)	10(69)	795.2	Discontinued	0.00	-0.04	0.68
6	IN100/Al2O3f +Al2O3p	800(1472)	10(69)	795	Discontinued	0.00	0.08	0.10
8	IN713/Al2O3f +Al2O3p	800(1472)	14(96.5)	795.4	Discontinued	0.00	0.09	0.35

Nominal Gage Dimensions: f 0.21 " x 1.4 "
Data Provided by: Metcut Research Inc.
Testing standard: ASTM E139

Since the creep testing is started at the higher designed stress level, two specimens (#1 and #3) failed during loading at stresses of approximately 16 ksi., the remaining specimens were tested at stresses 10 ksi and 14.5 ksi. The tests were discontinued after ~800 to 1180 hr due to negligible creep rates and the likelihood of slippage from the grips at higher loads.

The final creep of IN100/alumina particulates composite specimen(#2) was 0.06 (%) after 1178 hours at 800 C and 10 ksi stress. The static flexure strength of this composite was 81 ksi at 800 C--81. The recorded creep curve is given in Figure 1. shows creep strain as a function of time for IN100 reinforced with alumina particulates.

The IN100/Al2O3f+Al2O3p hybridized composite specimen displayed a slightly higher creep strain (0.08% after test termination at slightly less than 800 hr. as shown in Figure 2.

The hybridized specimen #8 (IN713/Al2O3f+A1203p), with nearly one and half time of stress level of other creep test specimens, had a relatively high primary creep during the initial 200 hr., after which the creep rate diminished to a negligible level until test termination after ~800 hr as shown in Figure 3.

The In 100/Al2O3f composite specimen #4 showed a negative creep of 0.04%. this was obviously an instrumentation error since the measured post test elongation was 0.68%.

The Metcut report along with the test specimens are being shipped to NASA for further evaluation.

3.0 Conclusion

The specimen design was not appropriate for creep testing. We were not able to apply a sufficient load to adequately evaluate the creep behavior of these materials. Since the stress level applied to creep testing was probably too low, it was not possible to analyze the creep failure mechanism operating in these composite materials.

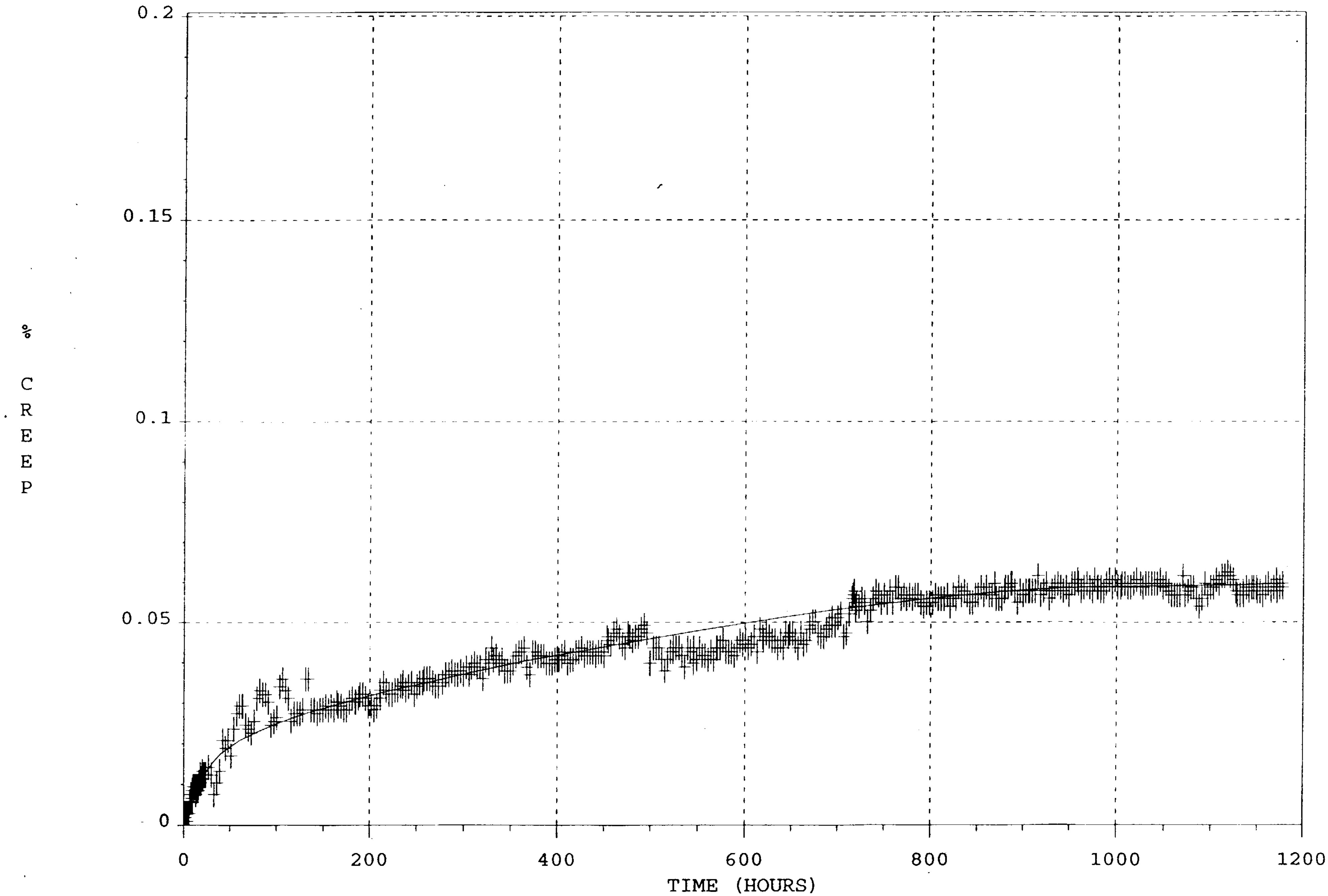

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Fig. 1

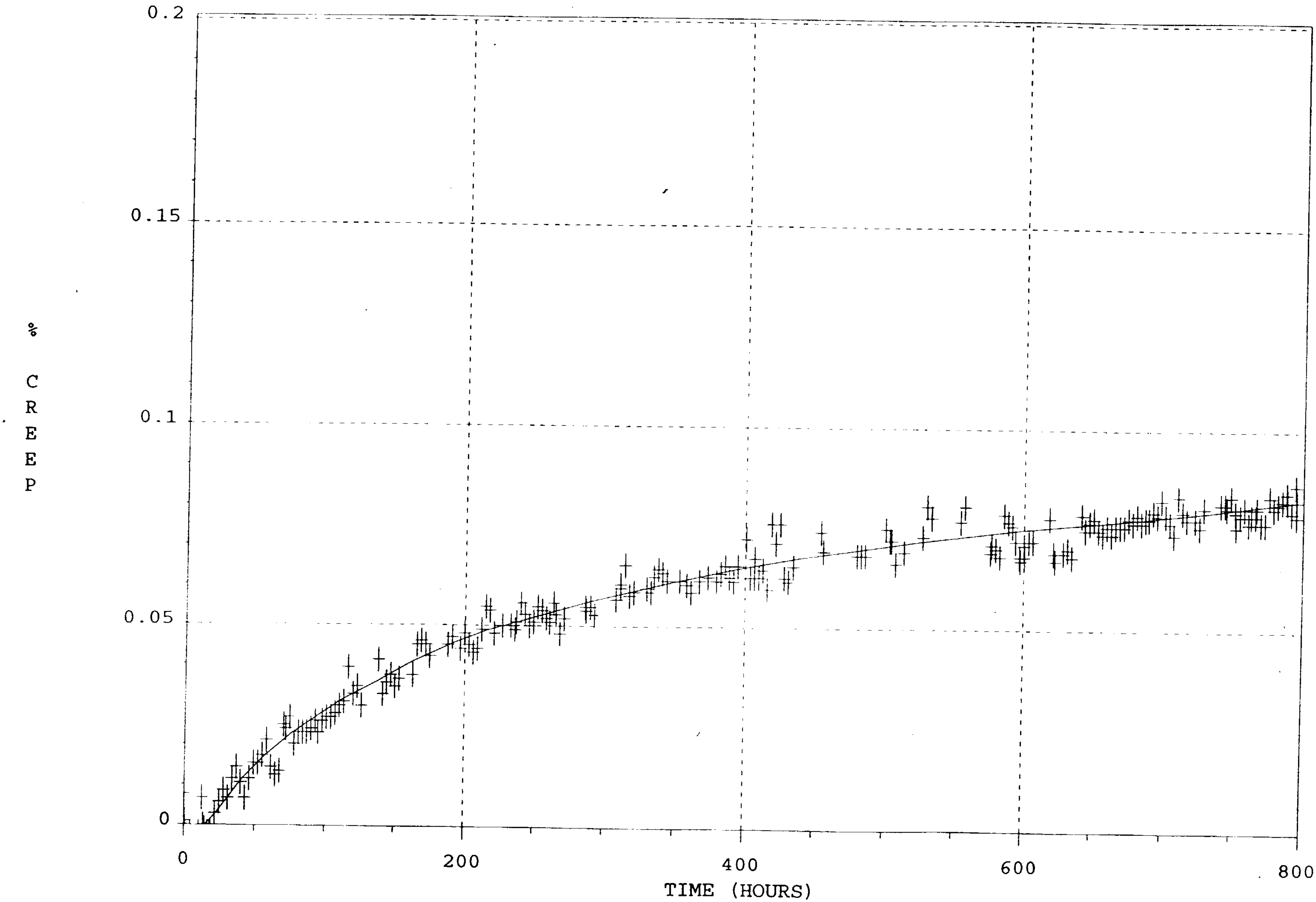

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Fig 2

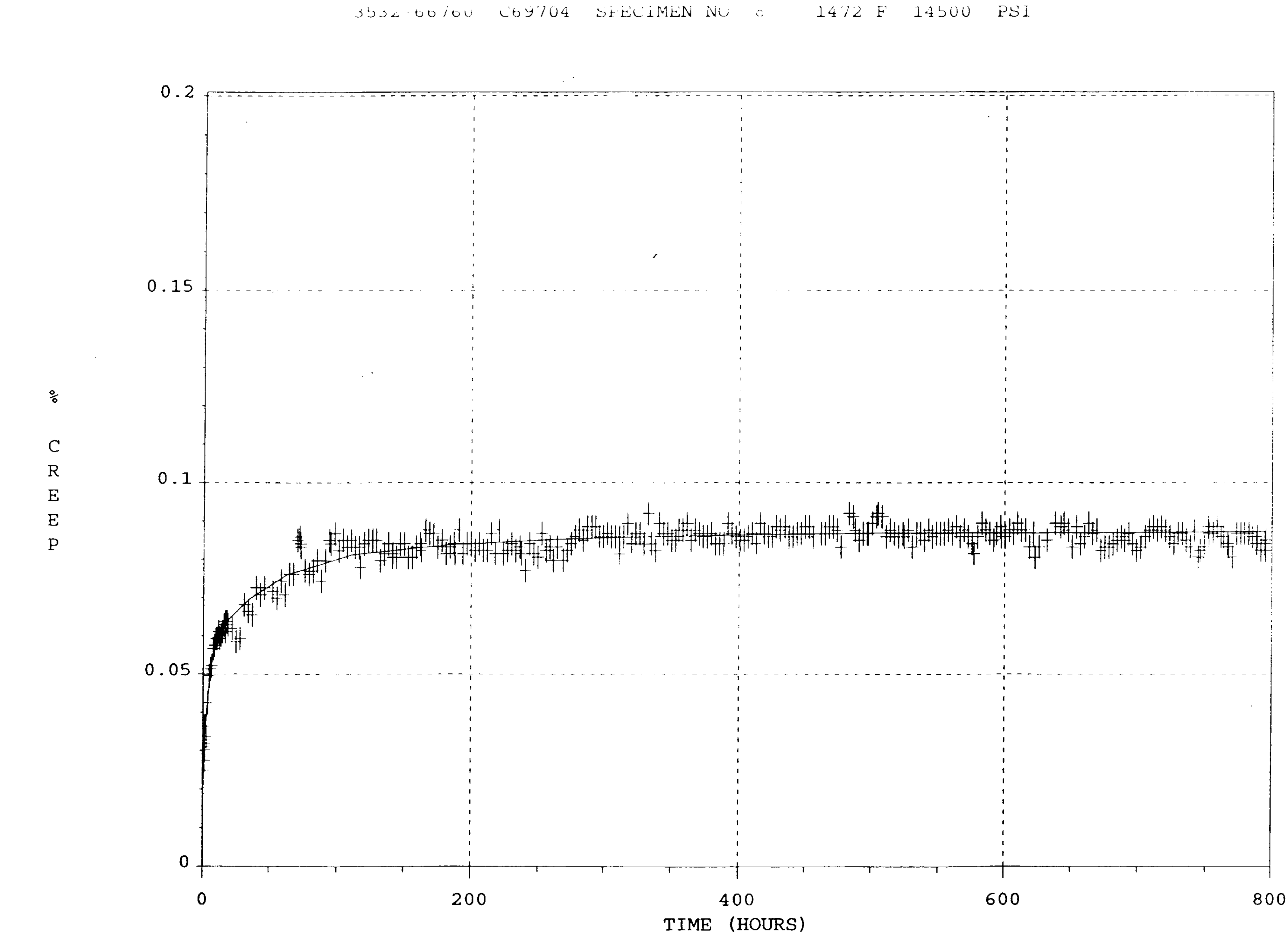

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Fig 3

NAS3-27541

LABORATORY REPORT

METCUT

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OCT 13 1997

Metcut Project: 3532-66760-1
Date: October 7, 1997
Authorization: 022897-R-2

Project: Creep Testing of Six (6) Metal Matrix Composite Specimens Machined By Metcut From Material Supplied and Identified by MMCC, Inc

Material: IN-100 and IN-713 reinforced with alumina particles or fibers
Testing to ASTM E139
Drawing No.: MMCC-1
Nominal Gage Dimensions: 0.21 in. dia. x 1.4 in. egl

MRAI Number	Specimen Ident.	Temp. (F)	Stress (ksi)	Time (hrs) to % Creep of 0.1	0.2	0.5	1.0	2.0	Duration (Hours)	Results	Plastic Strain on Loading	Final Creep	Elong. (%)	Red. of Area (%)
C69584	1	1472	35.0	---	---	---	---	---	FOL	Adapter	---	---	---	---
C69606	2	1472	10.0	---	---	---	---	---	1177.7	Discontinued	0.00	0.06	-0.10	---
C69585	3	1472	35.0	---	---	---	---	---	FOL	Adapter	---	---	---	---
C69703	4	1472	10.0	---	---	---	---	---	795.2	Discontinued	0.00	-0.04	0.68	---
C69702	6	1472	10.0	---	---	---	---	---	795	Discontinued	0.00	0.08	0.10	---
C69704	8	1472	14.5	---	---	---	---	---	795.4	Discontinued	0.00	0.09	0.35	---

Note: FOL = Fractured On Loading

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Creep, Stress Rupture and Tensile Testing

Mark J. Roetting
Testing / Systems Specialist

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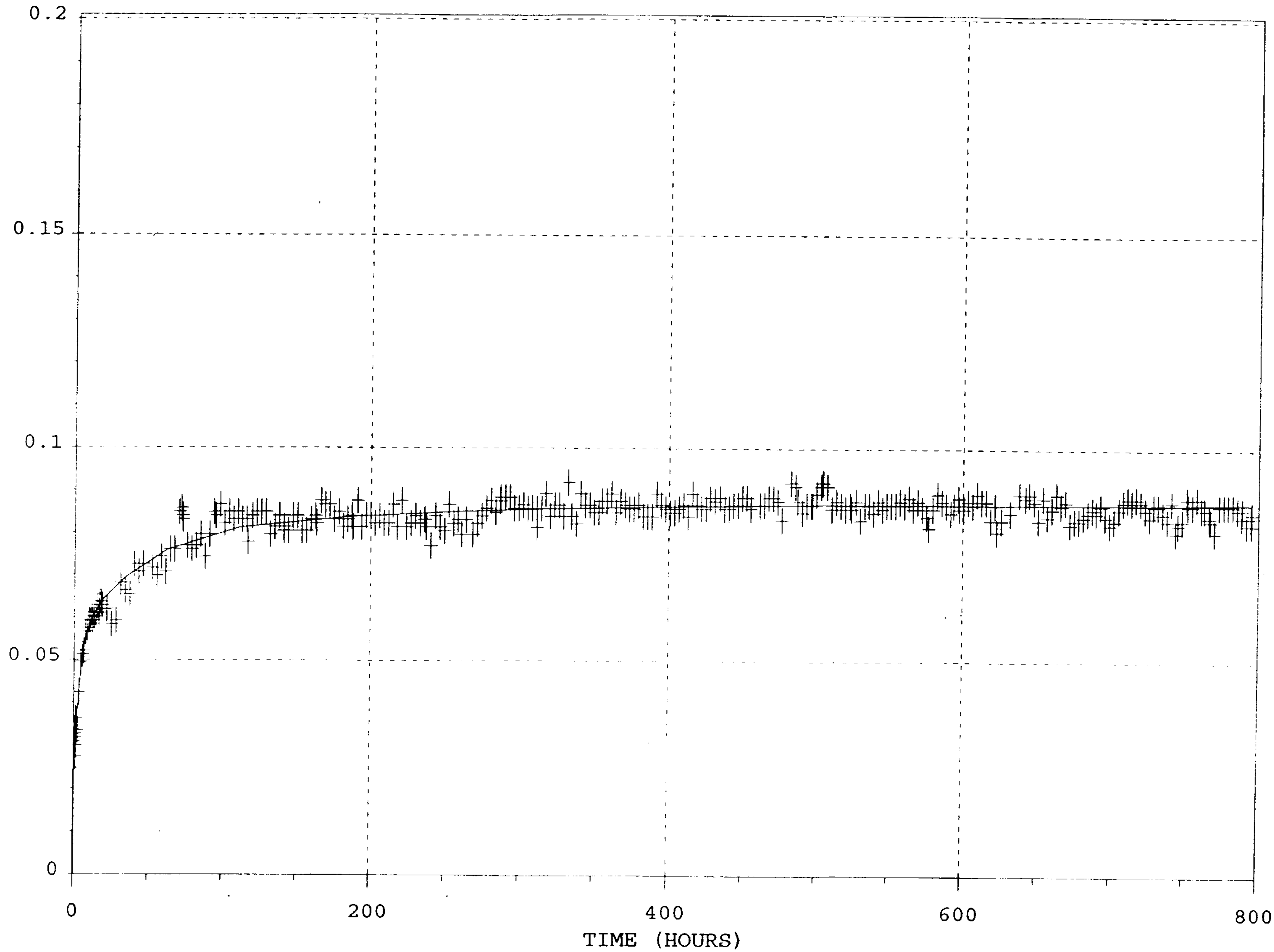
3532-66760 C69704 SPECIMEN NO 8 1472 F 14500 PSI



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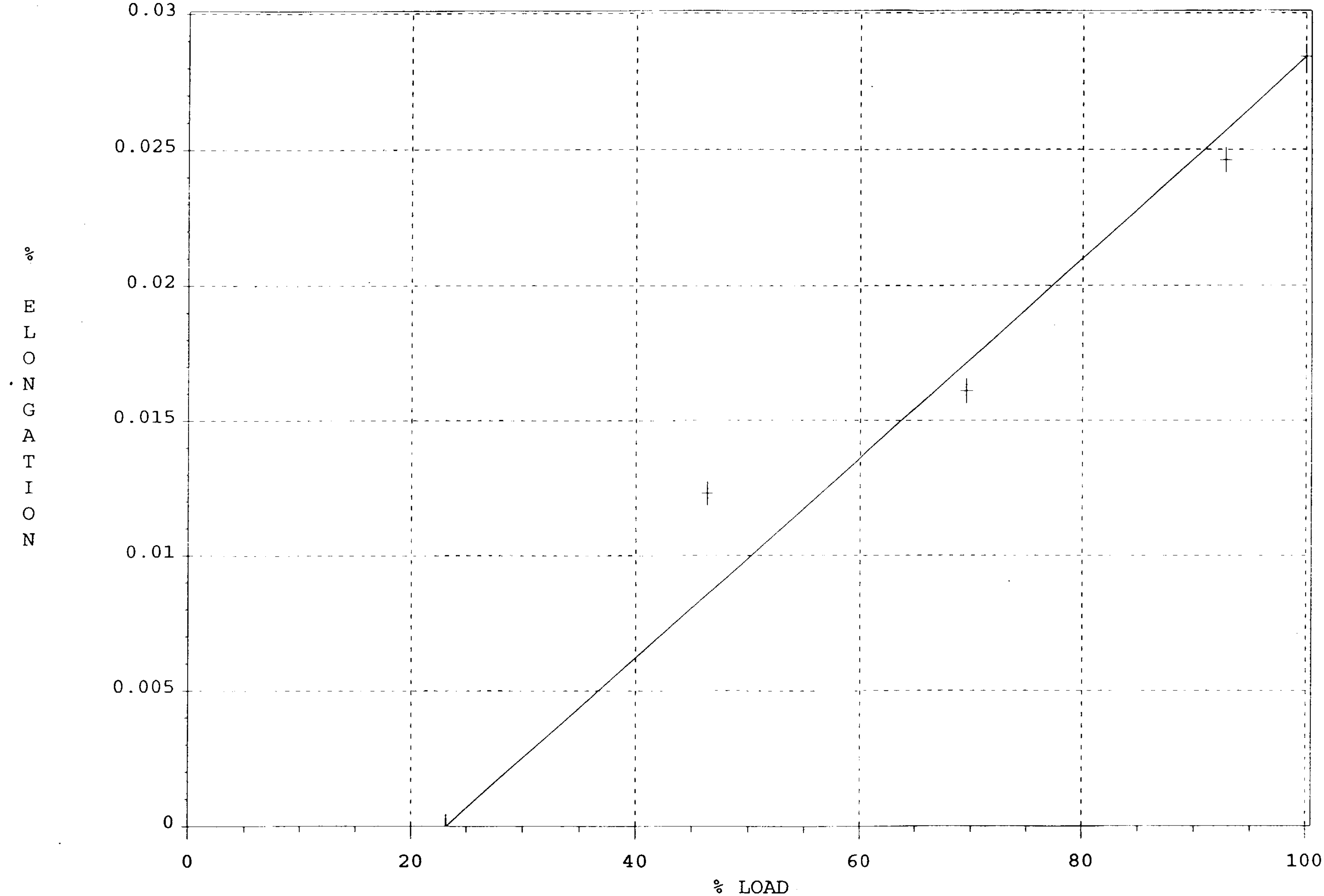
3532-66760 C69606 SPECIMEN NO 2 1472 F 10000 PSI



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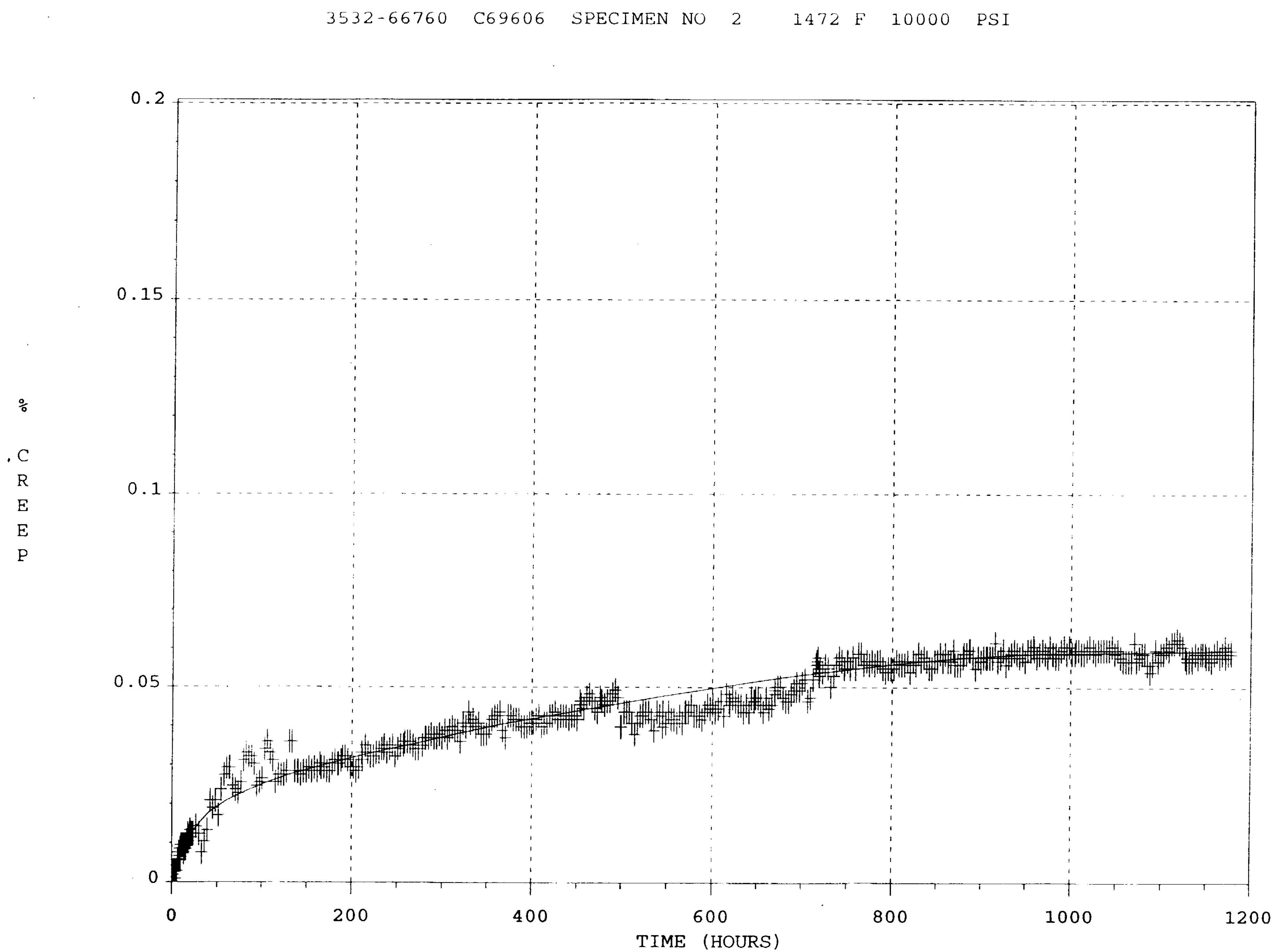

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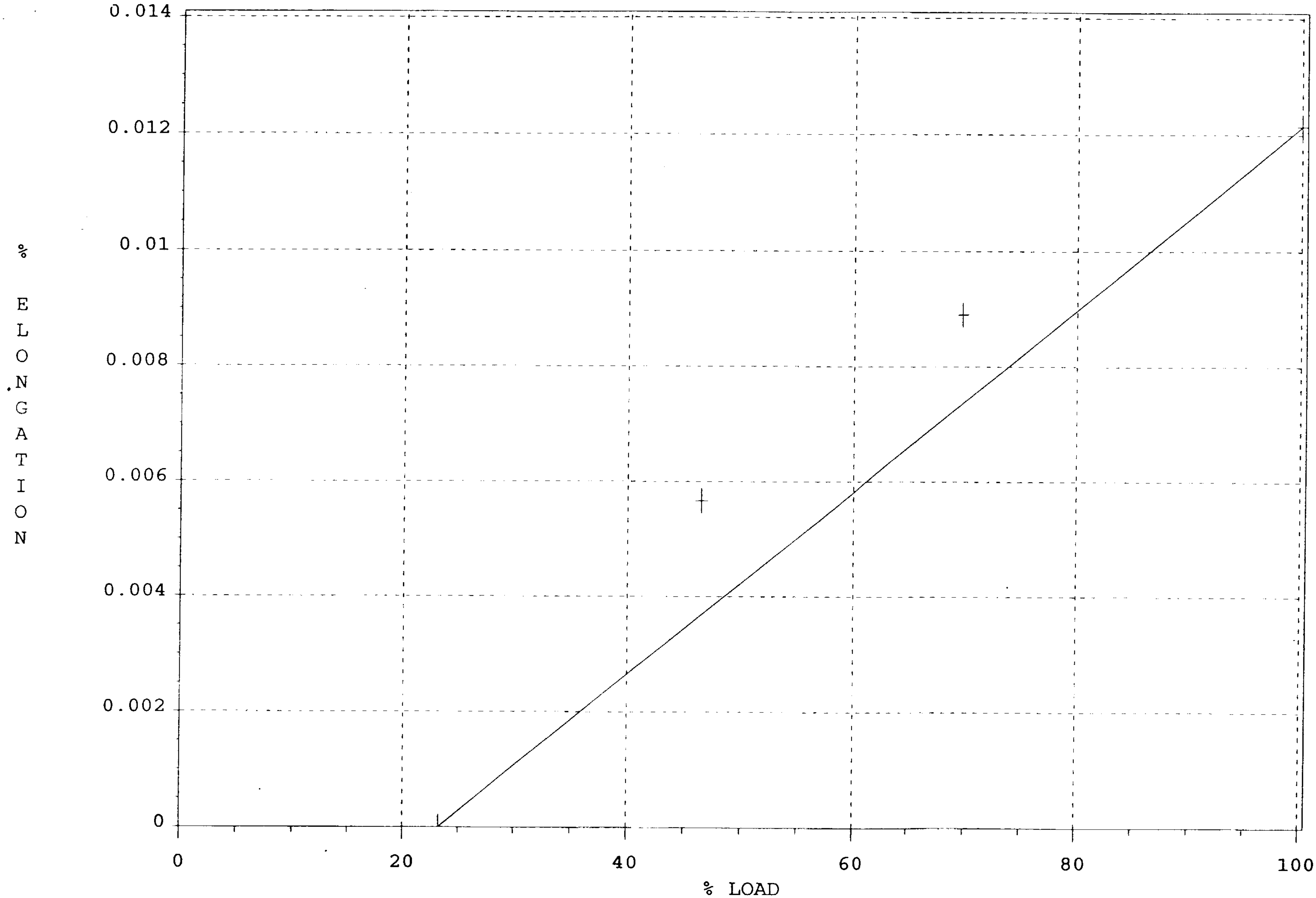

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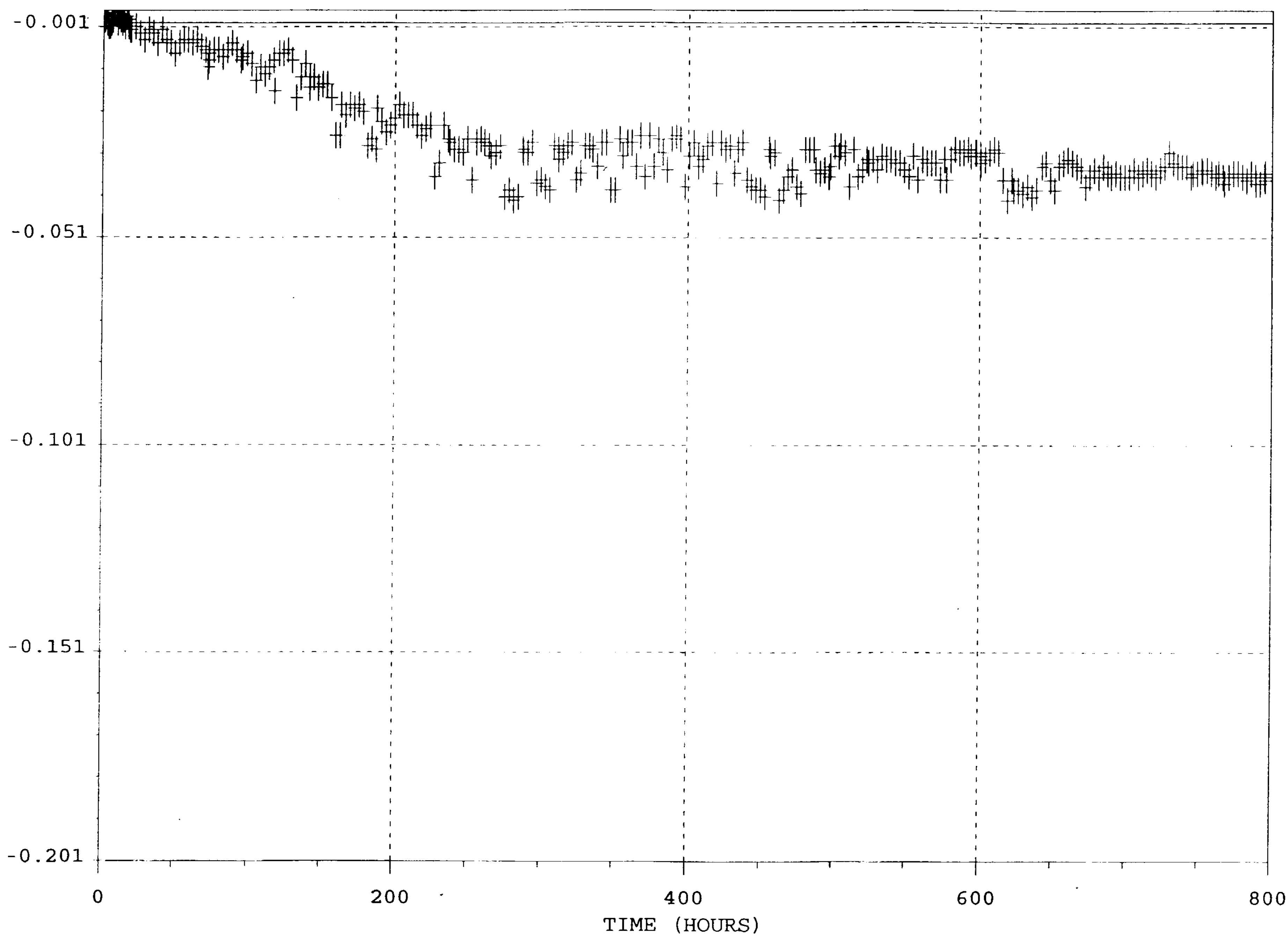

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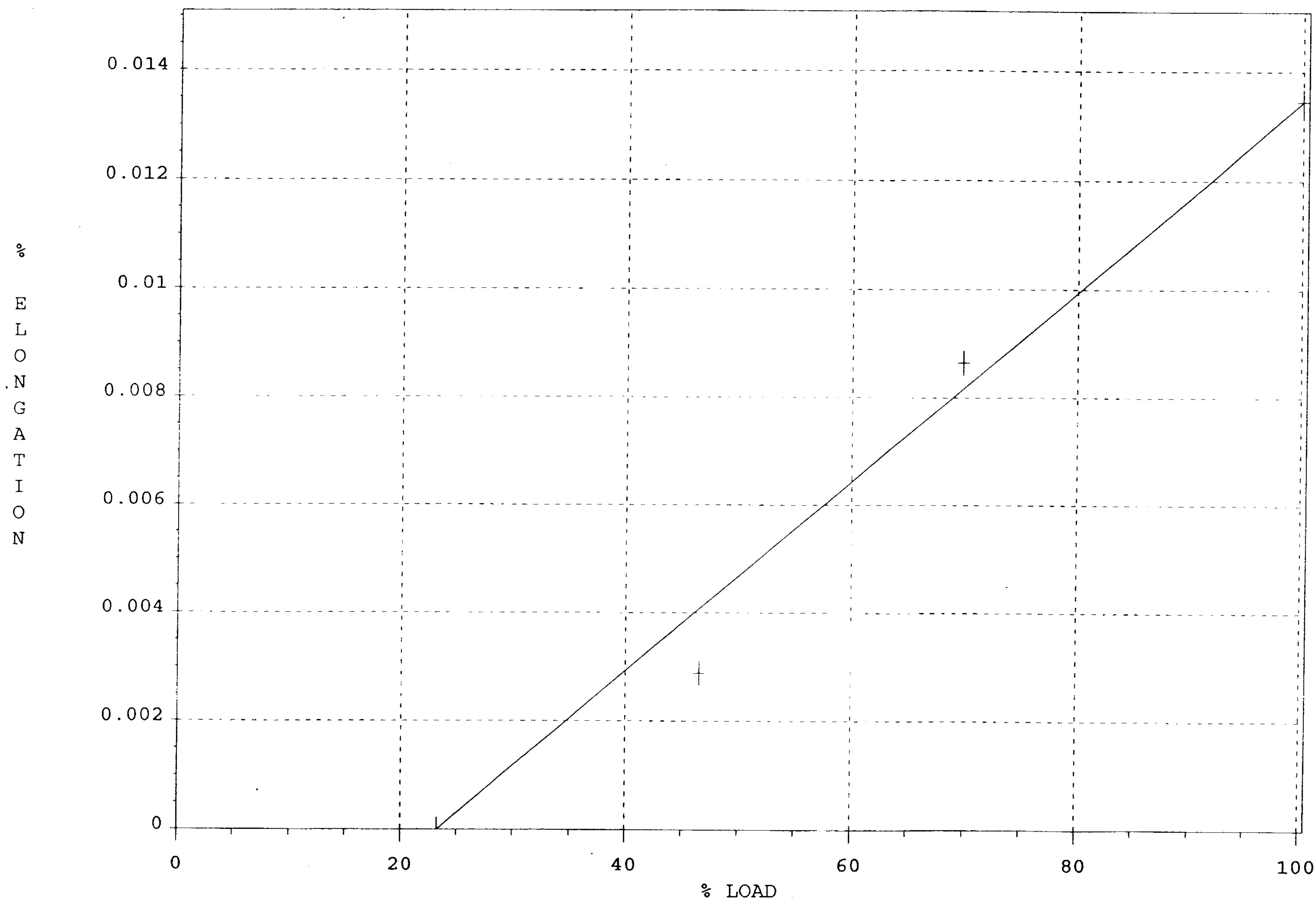

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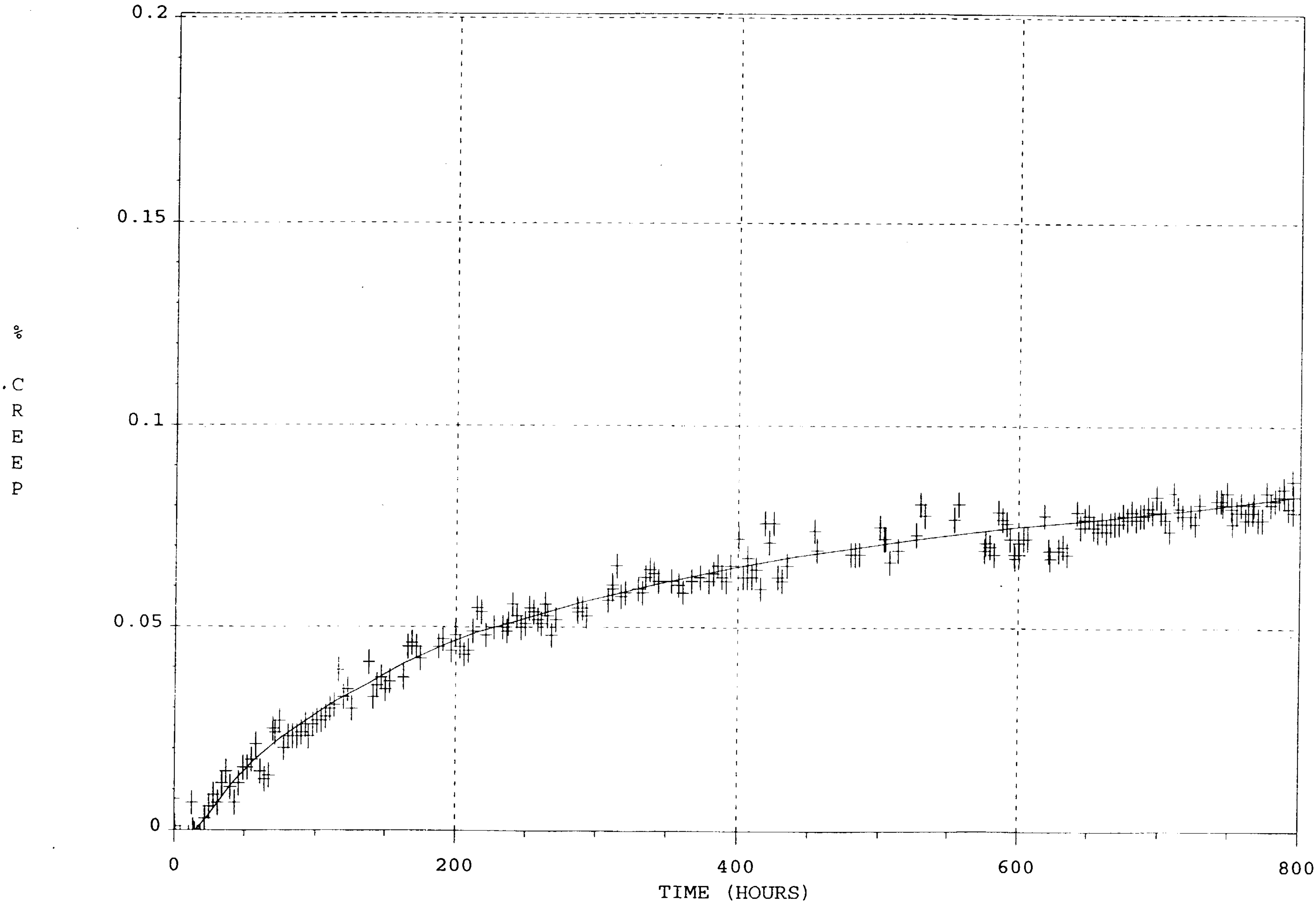

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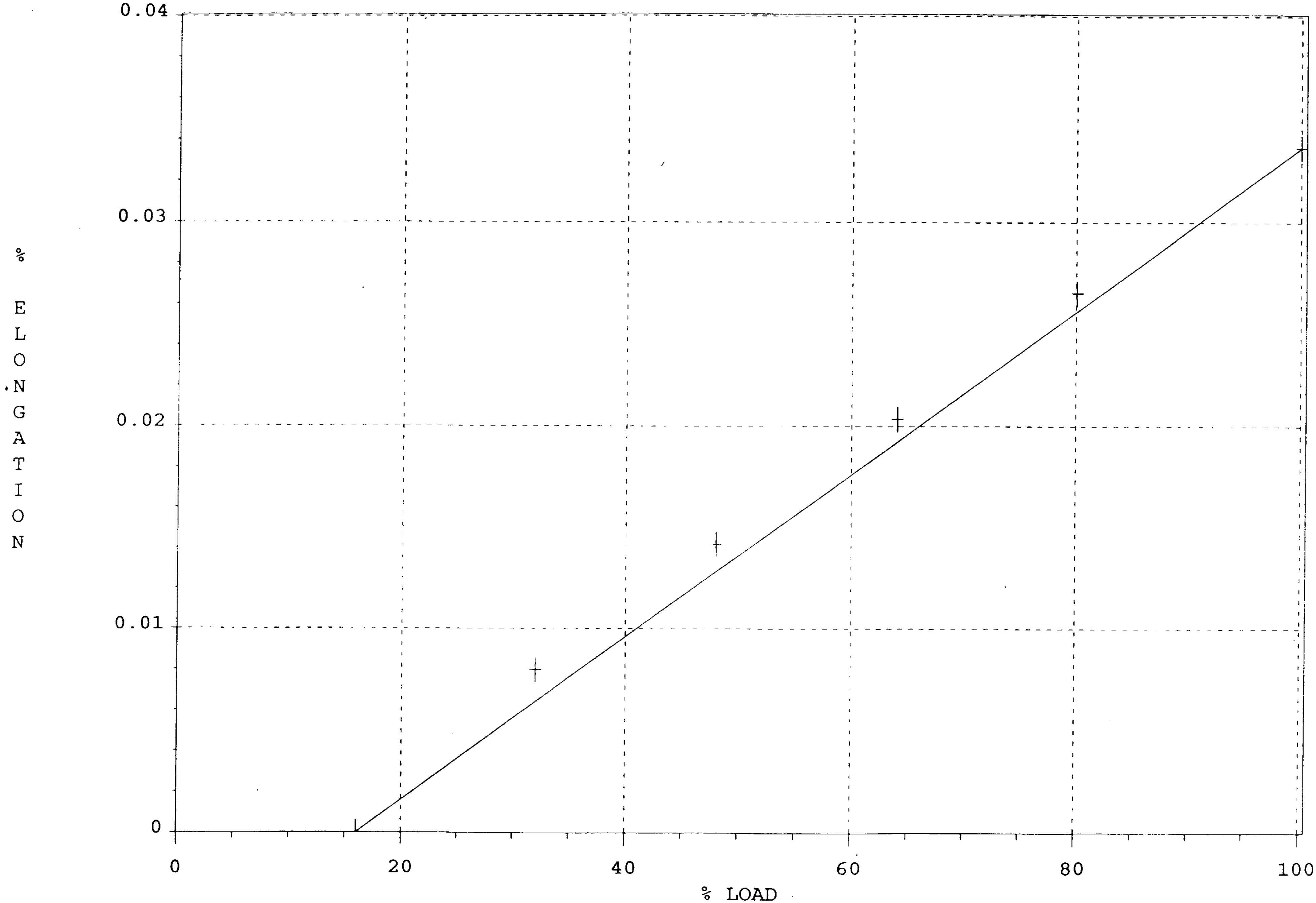

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13. ABSTRACT *(Maximum 200 words)*

This study featured development of a manufacturing process for fabricating evaluation specimens of alloys; IN100, IN718, IN713, and HA214, reinforced with 15 micron alumina, Nextel 610 alumina fibers and hybridized reinforcements of Nextel 610 fibers with interfiber spaces filled with 3um alumina or TiB2 particles. Specimens were evaluated at 20C, 800C, and 20C after six thermal cycles from 20C to 800C. Consistently high strengths of 700 to 800 MPa were measured for the alumina particle reinforced systems at 20C with best values obtained from the IN100 matrix. Alumina fibers were degraded by processing. However, best 20C strengths averaging 1240 MPa were measured for the IN713/Nextel 610/Al2O3p system where the hybridizing particles resulted in non-touching fibers. Hybridized systems also gave the best strengths at 800C with values of 800 MPa measured for IN713/Nextel 610/Al2O3p and for IN718/Nextel 610/TiB2p. Strengths after thermal cycling were generally lower. The best matrix system for resisting thermal cycling damage was IN100 where all of the reinforcement systems resulted in strengths from 500 to 650 MPa. Future efforts should concentrate on simple particulate alumina reinforced matrices with the emphasis on alloy refinement, interfaces and heat treatment. Tooling materials are needed.

14. SUBJECT TERMS

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